Thermal vacuum tests on the Amica lens

Report

1. Lens Focus

Before the vacuum tests, a preliminary study has been performed to study focus depth of the RODENSTOCK objective (75mm, f/1.25) selected for AMICA on AMS. Comparison with mechanical design has been made to understand if the design in compatible with focus position.

The main goal was to understand how large should be the regulation range on AMICA and the precision required for the positioning of the CCD with respect to the objective.

1.1. Experimental setup:

List of the items mounted on the optical bench from source to detector and acquisition:

- He-Ne 5mW red laser;
- Grey filter to attenuate the beam (up to 10^{-8}) ;
- Mirror to increase the optical path length and provide a sufficiently large beam to the next step;
- Laser beam expander 20x with input aperture of 3mm;
- θ, φ table;
- RODENSTOCK objective with depth regulation via M70x1 mounting;
- 388x285 CCD (no window);
- Acquisition board and PC.

The whole optical bench is kept under dark conditions. Additional light shielding is applied to the objective-CCD volume.

The scheme of the CCD-objective mounting is reported in the next figure. Distances from the objective will refer in the following to the stop position.

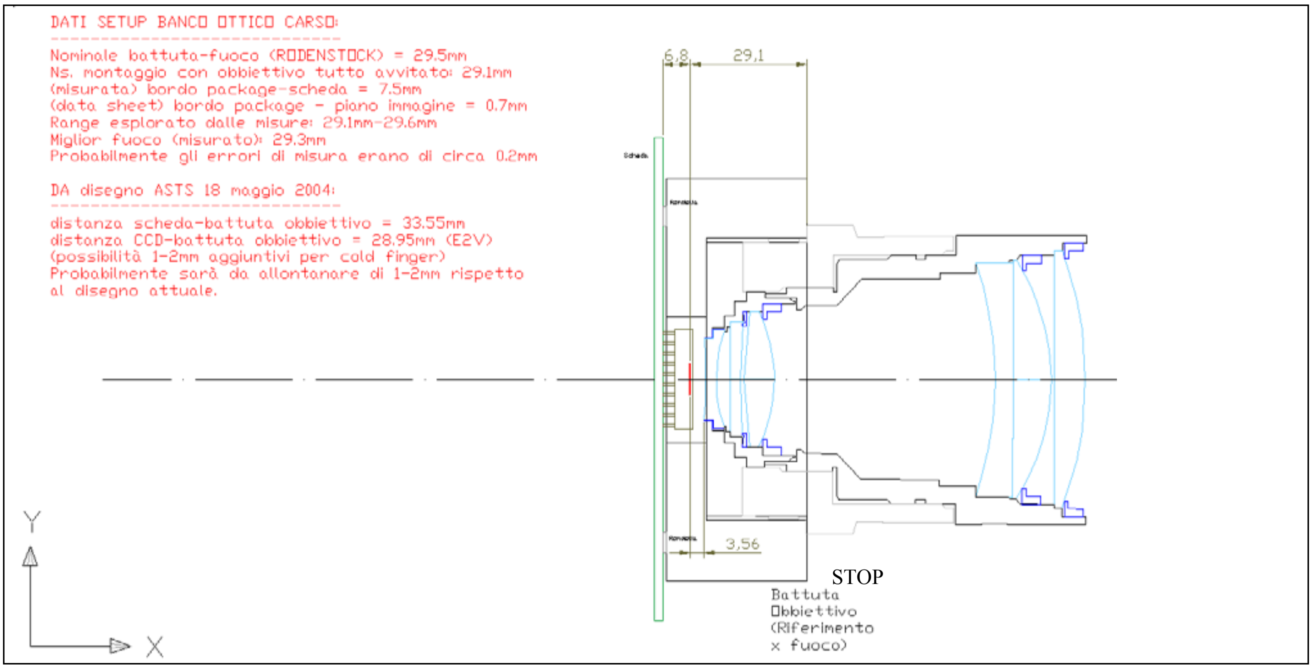
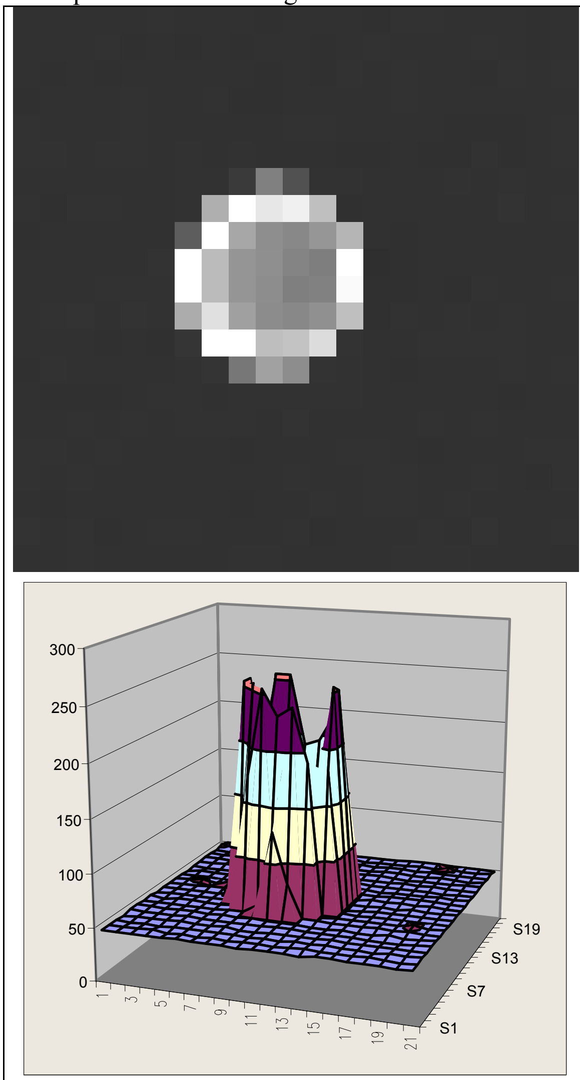
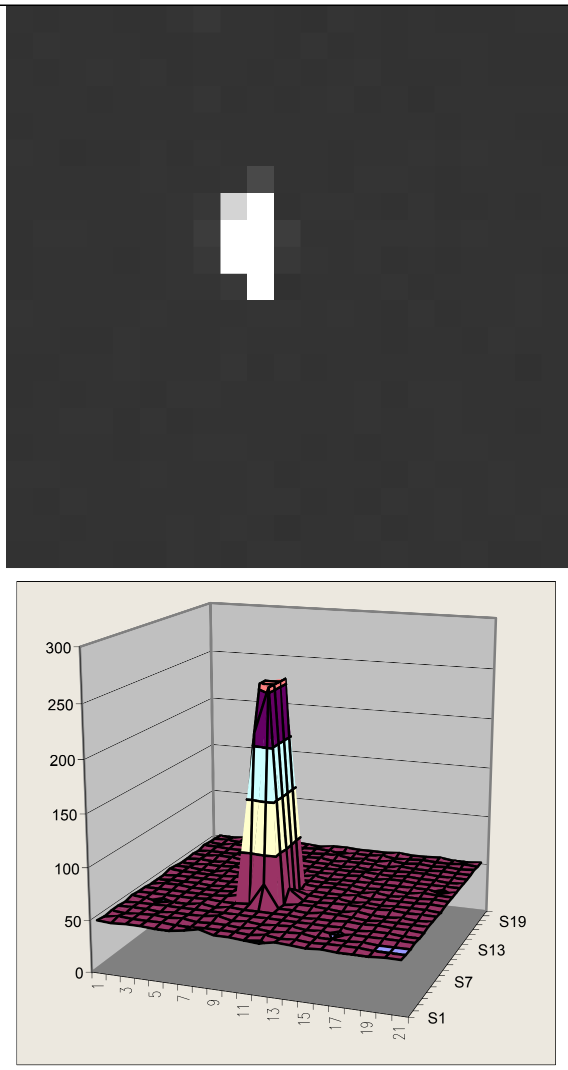


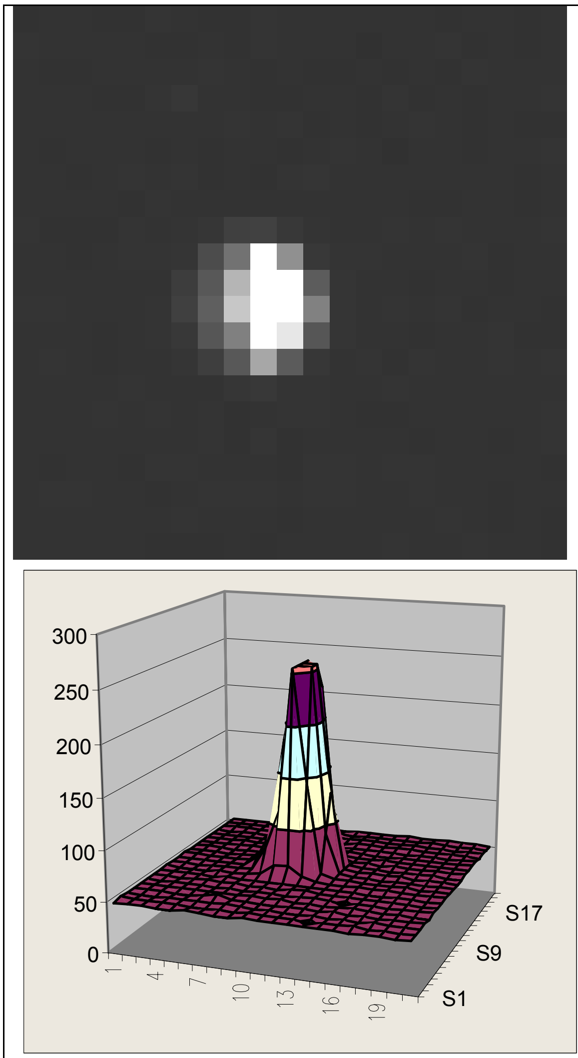
Figure. *CCD-objective interfacing drawing. The quotes are nominal, and suffer from an error of about 0.2mm mainly due to the error introduced by CCD packaging specifications. A fixed offset will be derived by matching the RODENSTOCK specifications with our measured best focus.*

The fine regulation (about 0.02mm step) of the objective-CCD distance is achieved by de-screwing the objective from the stop position shown in figure. The M70x1 screw and a graduated scale all over the objective external surface allows the change in CCD-objective distance in 0.028mm (1/36th of a mm) steps.
As in the figure, the nominal stop distance (starting point) is 29.1mm from CCD image plane. In this case, the clearance between the objective last lens and CCD package is less than 3mm.

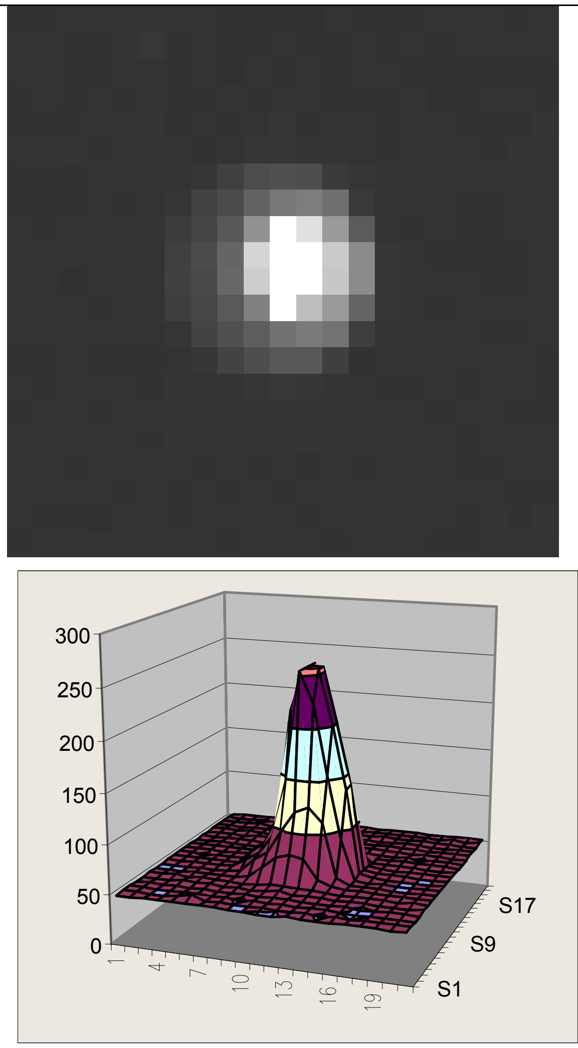
From RODENSTOCK specs, the focus distance in air (no glasses in between) is at 29.5mm.

We explored, by de-screwing the objective by half a tour, the (nominal) distance range 29.1mm to 29.6mm. The spots are reported in the next figures:

	
29.10 mm	29.29 mm



29.38 mm



29.46 mm

It is evident that the resulting optimal focus is around 29.3mm. The error associated with the CCD package to image plane distance is 0.2mm (from CCD data sheet), so that this measurement is in agreement with the RODENSTOCK specifications that we assume correct with negligible uncertain.

The measured offset of the stop position is thus +0.2mm. The focus depth is quite small: a 0.3mm displacement already led to a large defocusing.

2. Vacuum test

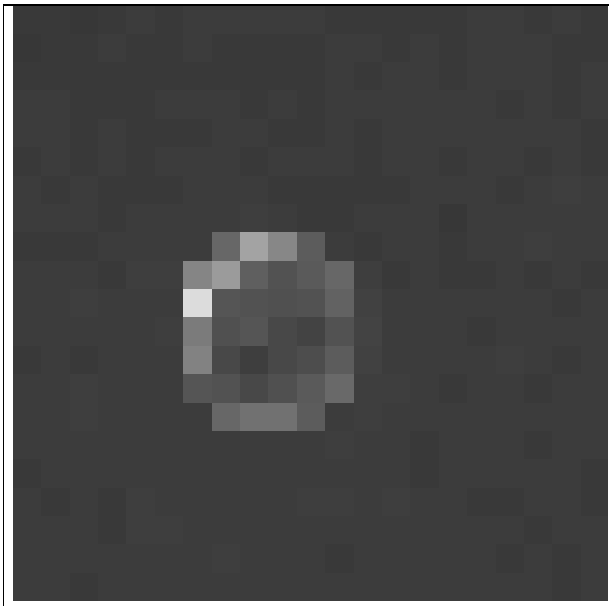
2.1. First test

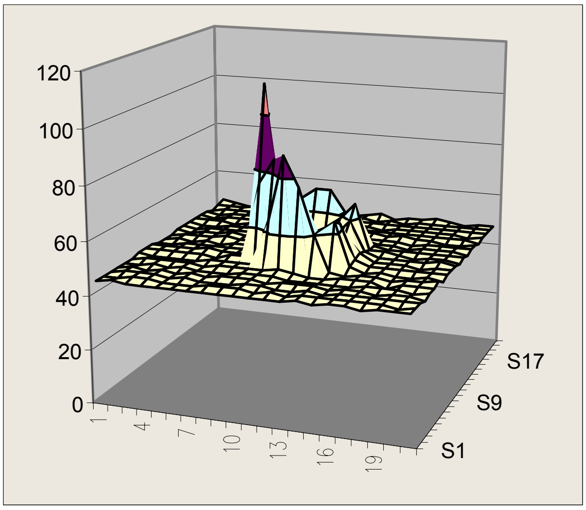
A first test was performed in a thermal-vacuum chamber at few mbars. No visible damage was noted on the lens after the test.

2.2. Other tests

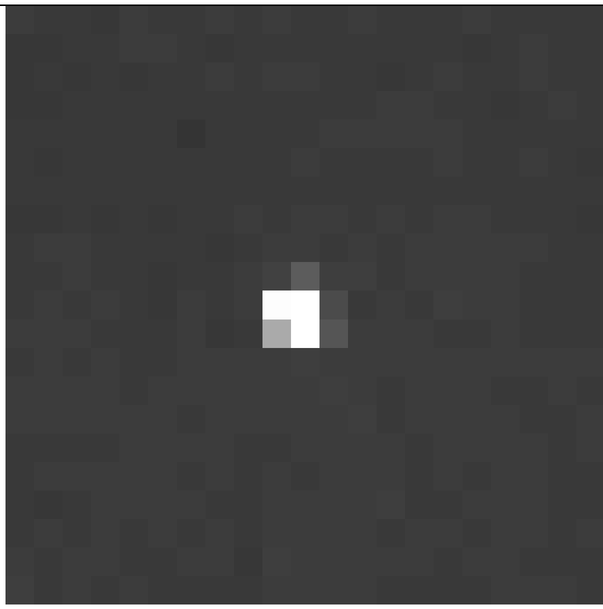
Various tests performed in a vacuum chamber at ≈2e-6 mbars (see Appendix). No visible damage was noted on the lens after the test.

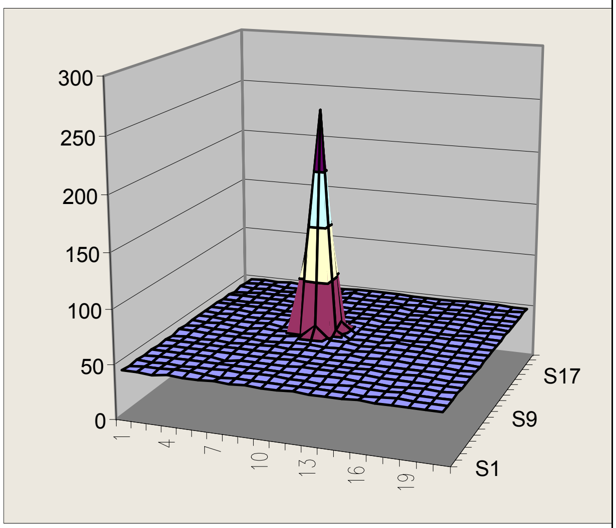
2.3. Focus after vacuum



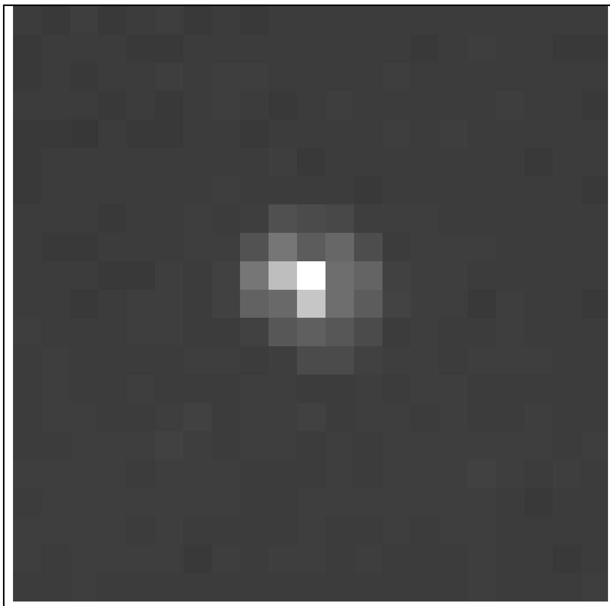


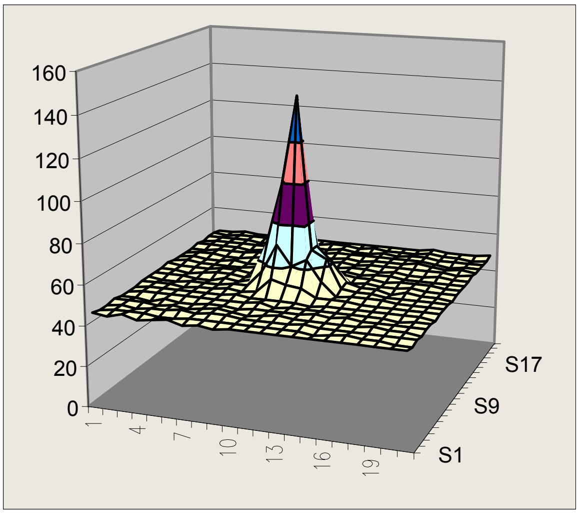
After vacuum
29.1 mm (completely screwed)



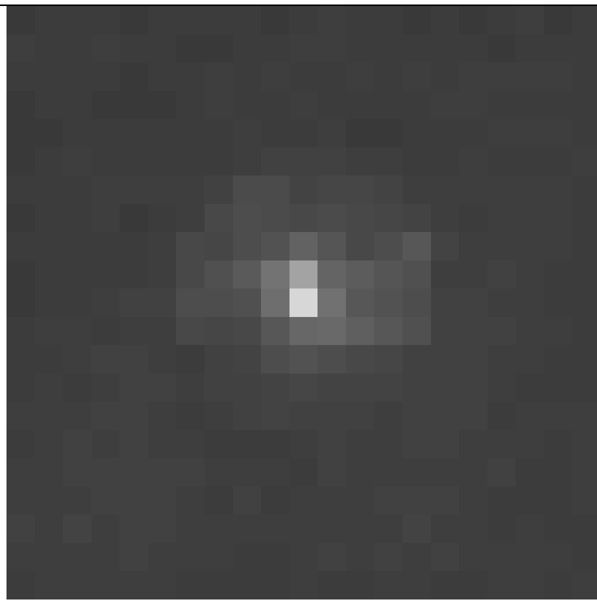


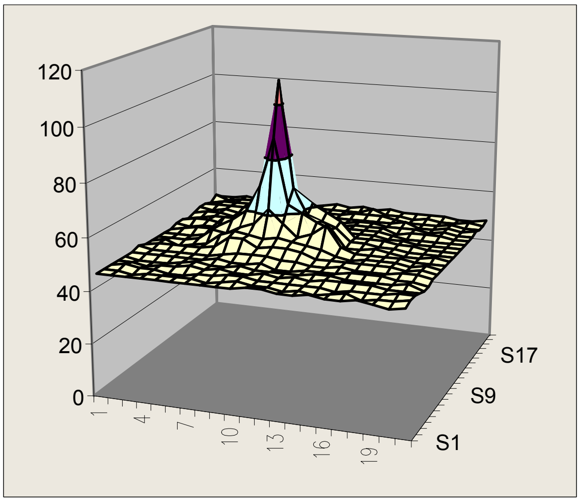
After vacuum
29.29 mm





After vacuum
29.4 mm



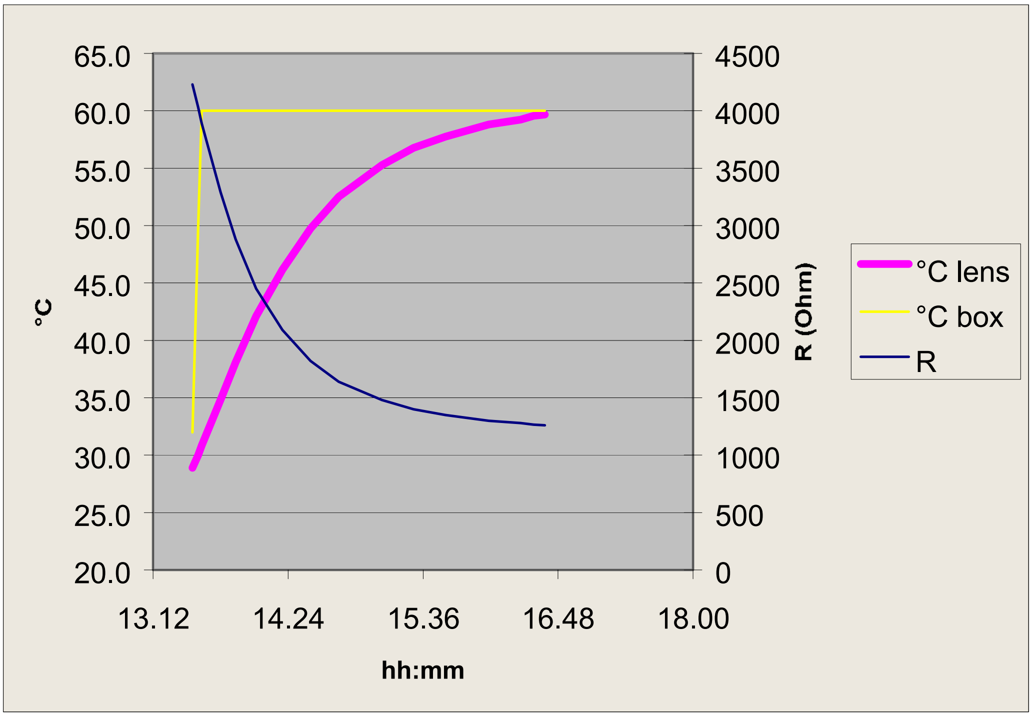


After vacuum
29.51 mm

As can be observed from the figures, the focus doesn't change after the vacuum tests: it remains at a distance of 29.29 mm.

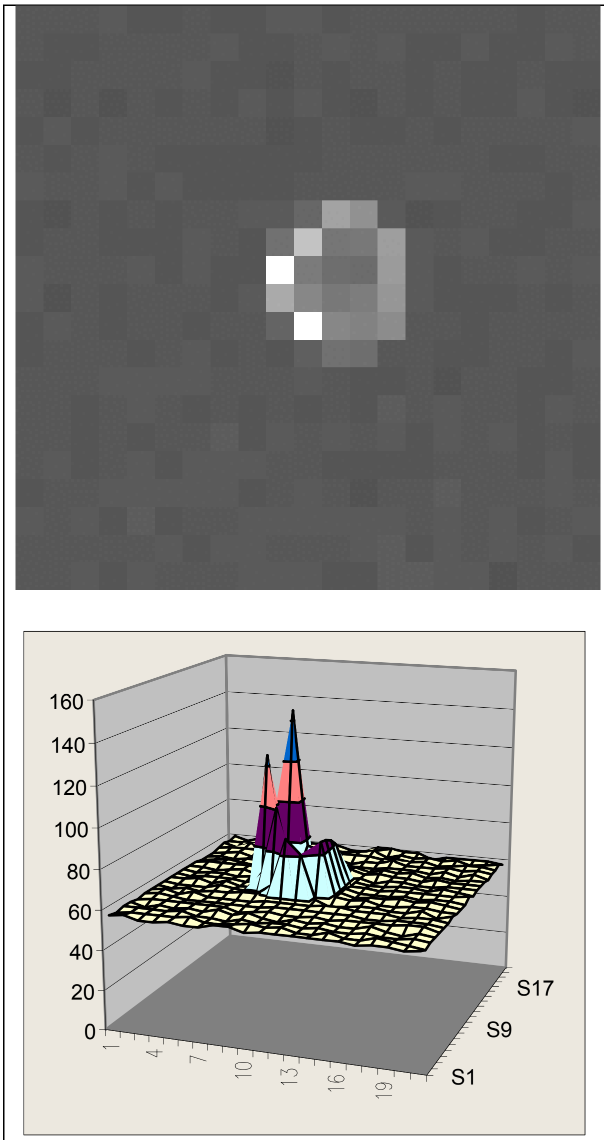
3. Thermal vacuum test at 60°C

Performed in the thermal-vacuum chamber at few mbars. In the following figure the yellow curve represents the temperature of the chamber, while the purple curve is the temperature of the thermistor on the lens.

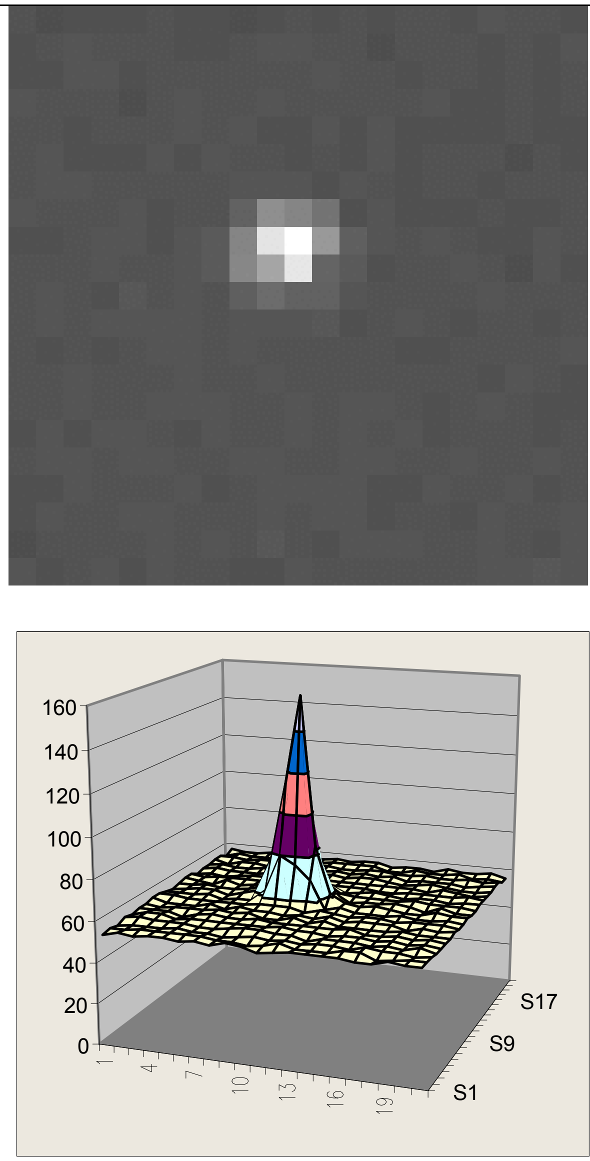


Thermistor on the top of the lens collar

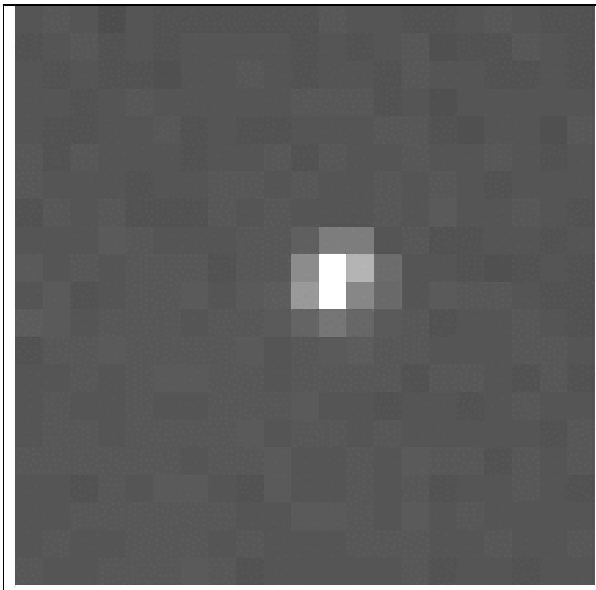
3.1. Focus after tests

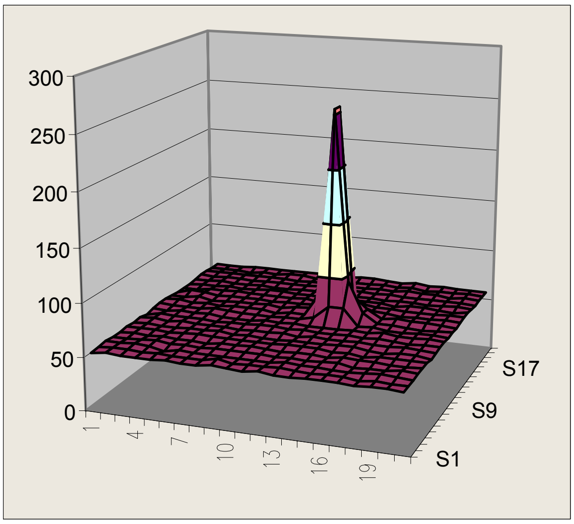


After thermal vacuum 60°C
29.1 mm

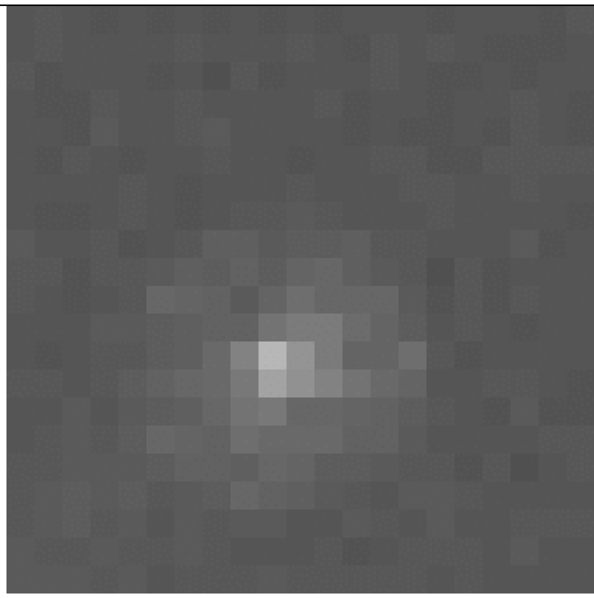


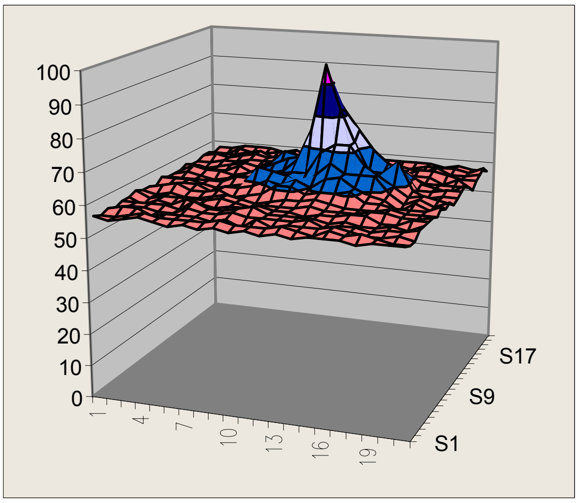
After thermal vacuum 60°C
29.3 mm hot





After thermal vacuum 60°C
29.3 mm less hot





After thermal vacuum 60°C
29.5 mm

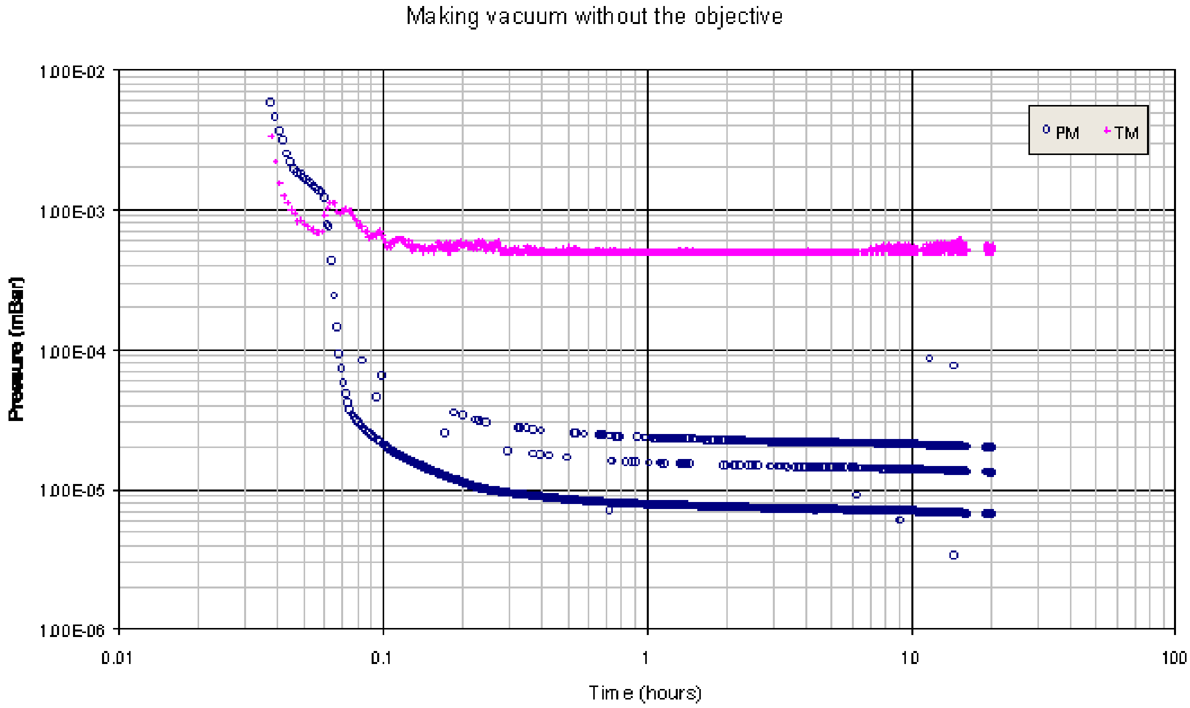
As can be observed from the figures, the focus doesn't change after the thermal-vacuum tests: it remains at a distance of 29.3 mm.

4. Conclusions

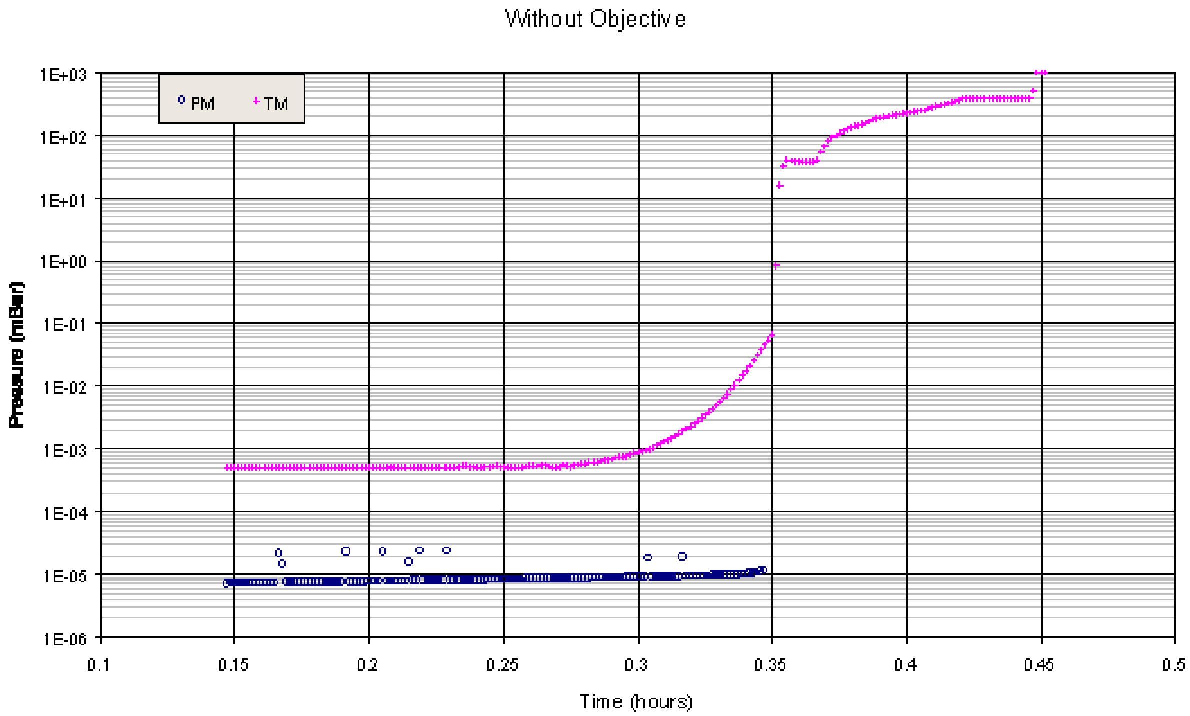
After the thermal-vacuum test, the lens doesn't show any damage and the results of the focus measurements on the bench are the same as the ones obtained before the tests.

5. Appendix: Vacuum tests

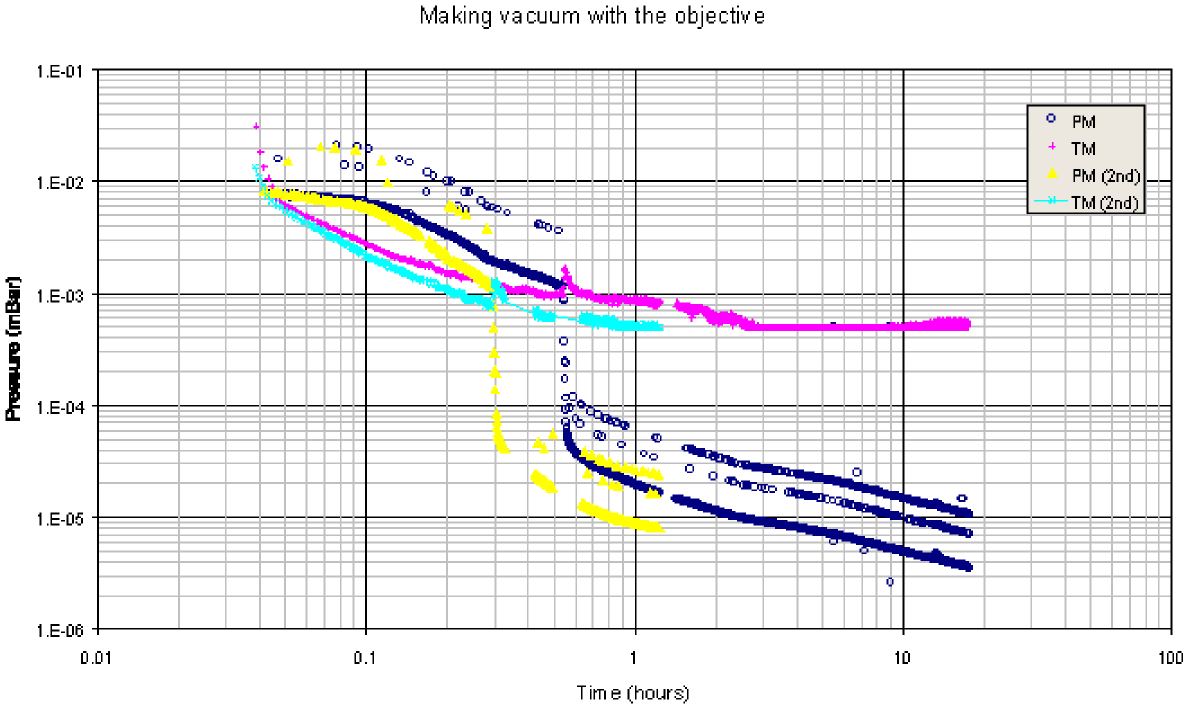
5.1. Vacuum Without lens

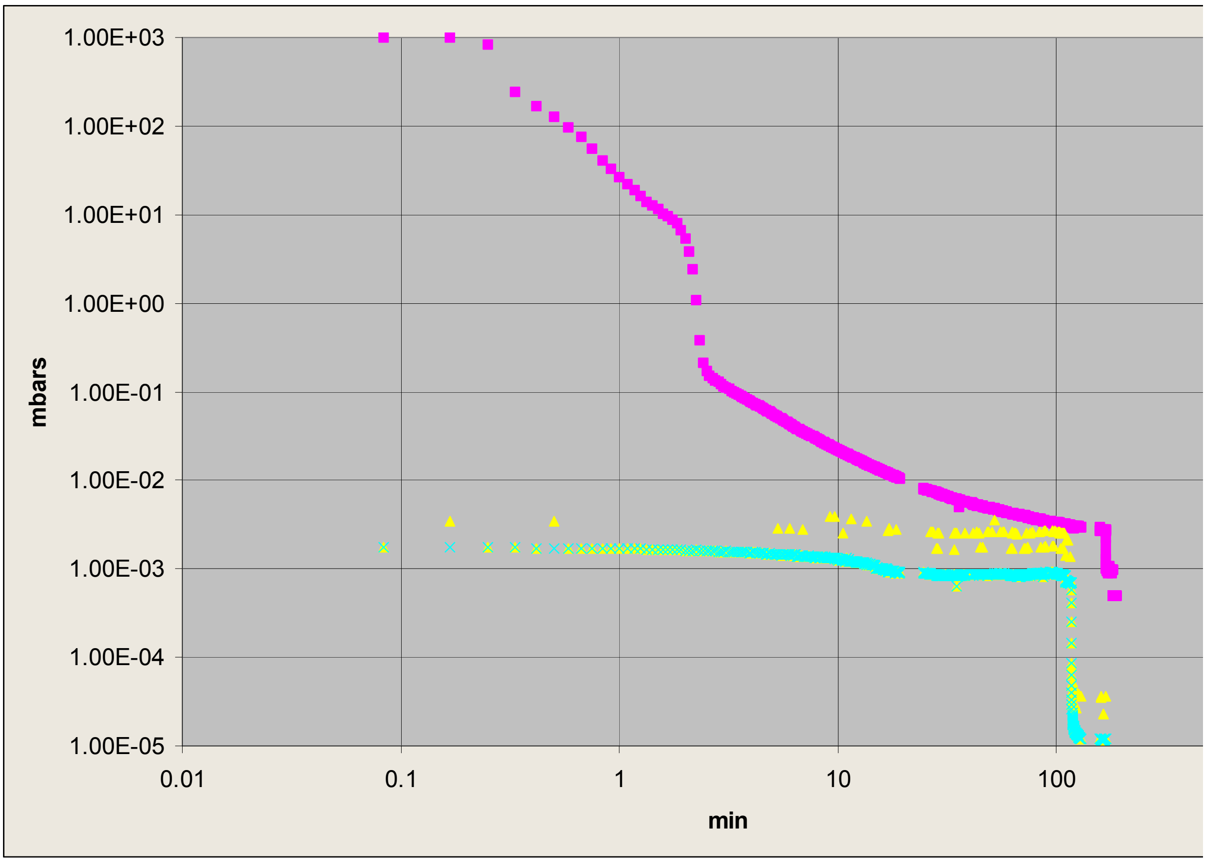


5.2. Venting without lens

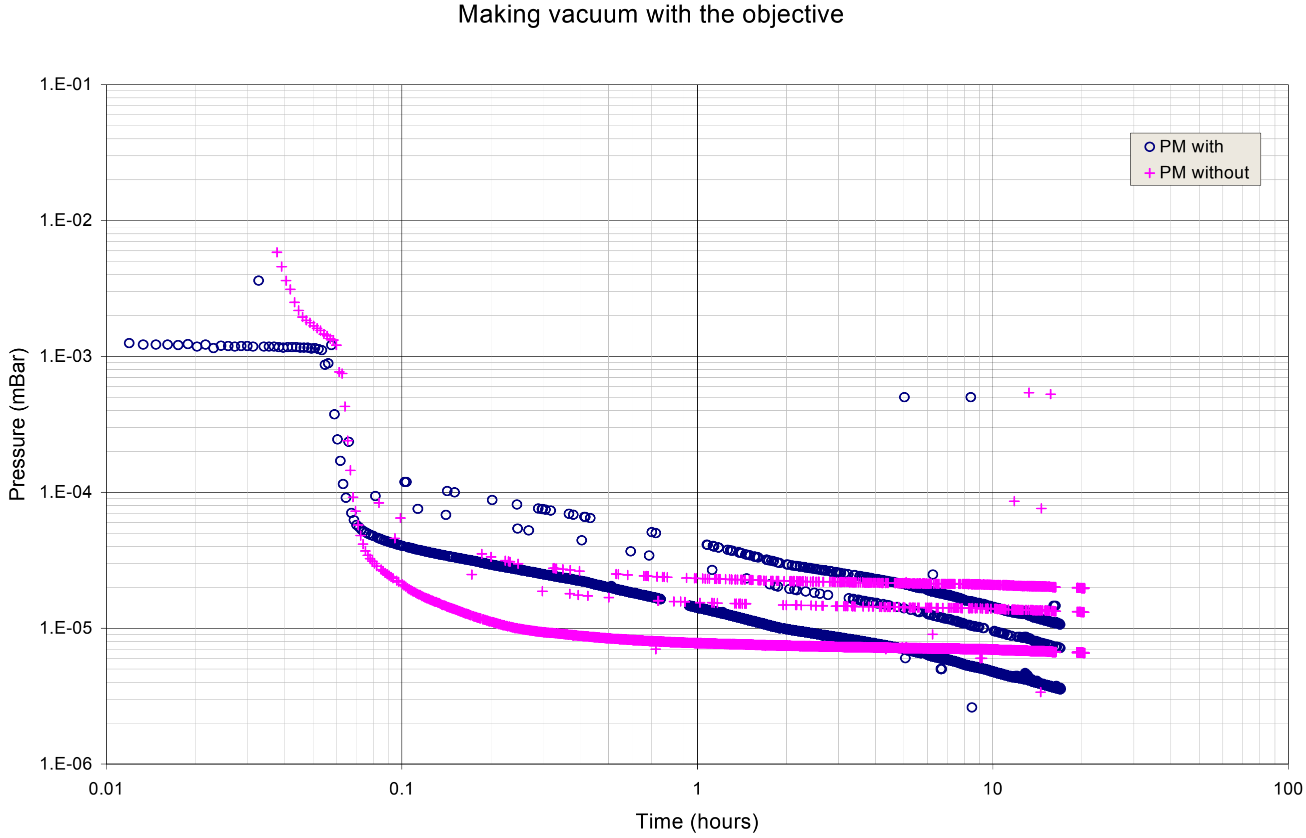


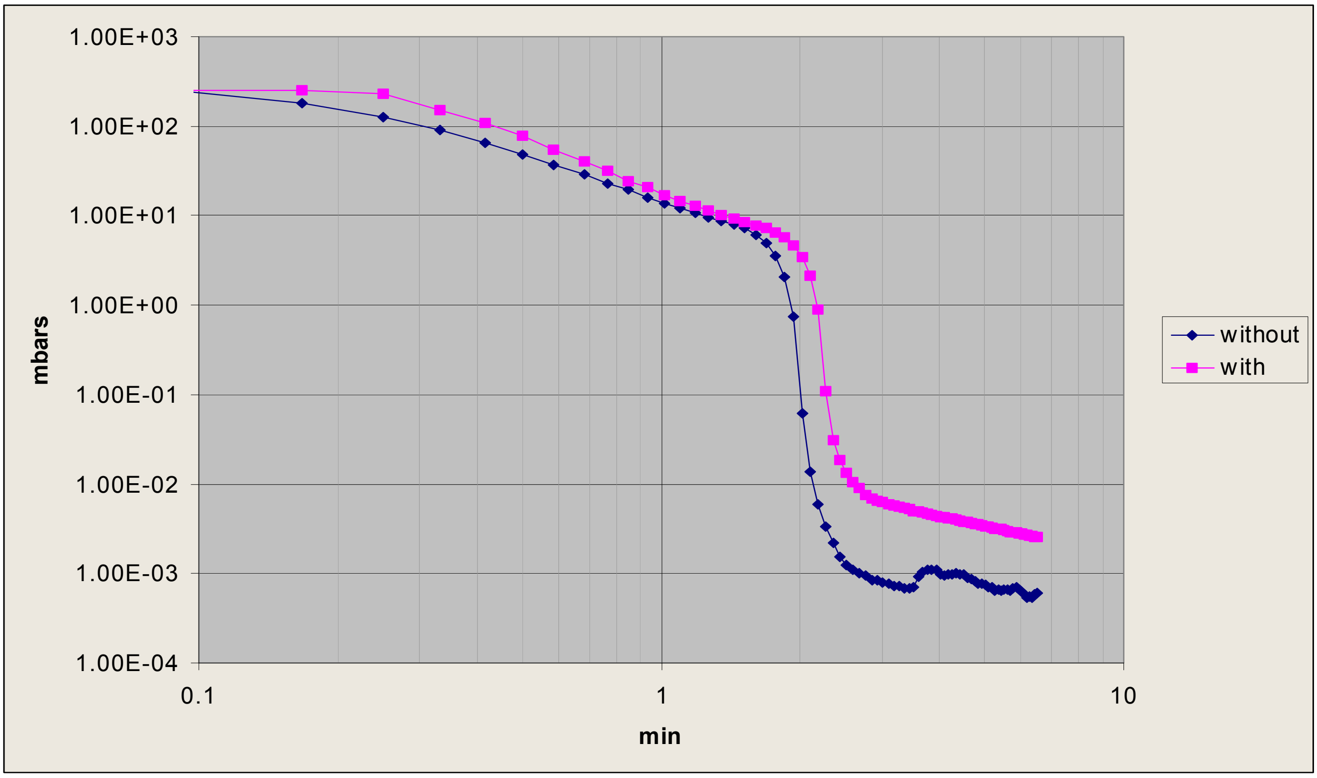
5.3. Vacuum With lens





5.4. Comparison of vacuum with and without lens





5.5. Second Test with lens